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DETERMINATION OF NET FLOWS INTO ALMATTI RESERVOIR FROM CWC GAUGE DATA AND RESERVOIR DATA

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ABSTRACT

This paper presents the determination of net flows into Almatti reservoir from CWC data and reservoir data. From the study it can be concluded that the average flow in to Almatti will be 574.86 TMC, the maximum inflow will be 1196.8 TMC and the minimum flow will be 166.99 TMC. The flows in annual in deficit years may reduce by about 50 TMC but there is no variation in the good years in the good years as the storage effects will take care of this aspect during good years. It can be concluded that there will be reduction of flows in the June and July flows in the ultimate scenario except in very good years.

Key words: Almatti, Netflows, CWC gauge data, working tables, Catchment

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1. INTRODUCTION

The River Krishna rises in the Mahadev range of the Western Ghats near Mahabaleshwar at an altitude of 1337m above sea level and flows through Maharashtra, Karnataka and Andhra Pradesh gathering water on its way from innumerable rivers, streams or tributaries and drops into the Bay of Bengal. River Bhima and Tungabhadra are major tributaries of river Krishna. Main Krishna, Bhima and Tungabhadra constitute the stems of the river Krishna. Jurala, Srisailam, Nagarjunasagar, Krishna delta are the major projects on main Krishna. Almatti reservoir was constructed across main Krishna in the state of Karnataka up stream of this reservoir s. This reservoir is very important as it has to cater to the needs of UKP project in addition to supplying water to downstream projects. The operation of this reservoir is very important for the system downstream.

Therefore it is proposed to estimate the inflows by considering the CWC gauge data available at various sites upstream of Almatti. This gauged data is available at the end of sub basin as well as at

some other sites from 1972 onwards. Therefore a monthly inflow series for the period 1972-73 to 2007-08 at Almatti is developed using these gauged flows.

The salient features of the Almatti reservoir are given below in Table 1.

Table 1 Salient features of the Almatti reservoir

S.No.	Name of the project	Unit	Almatti
1	Sub-basin		K-2
2	Catchment area	(Sq.Km)	35926
3	Gross storage	(TMC)	223.52
4	Live storage	(TMC)	205.98
5	Dead storage	(TMC)	17.57
6	F.R.L	m	524.26
7	M.D.D.L	m	
8	D.S.L	m	506.87
9	Length of spillway dam	m	486.50
10	Length of non-spillway dam	m	676.33
11	Length of earthen dam	m	402.00
12	Total length of dam	m	1564.83
13	Crest level	m	509.02
14	Number of gates		26
15	Gate size	mxm	15x10.584
16	Type of Gate		Radial
17	Design flood	Cumecs	31,007

2. LITERATURE SURVEY

An analytical method (AM) and a method using the ensemble Kalman filter (EnKF) are proposed by Chao Dung et.all to determine nonfluctuating reservoir inflow based on the concept of inflow continuity. The AM is developed based on the simultaneous minimization of both the estimated reservoir water level error and the inflow variation. The EnKF, which is built on state equations (inflow continuity and water balance equations) and an observation equation (the reservoir stage-storage relationship), is used to update inflow states by assimilating water level observations. The two proposed methods are evaluated using a synthetic experiment with various conditions including water level observation error, reservoir stage-storage relationship error, and the influence of water surface slope. The AM outperforms the EnKF under all conditions. Case studies of the Gaobazhou and Danjiangkou Reservoirs in China demonstrate that both of the proposed methods can derive an hourly inflow without fluctuations. The results indicate that the AM and the EnKF method can improve reservoir inflow estimation compared with conventional methods.

In this study Samuel Dixton and Robert Willy explores the feasibility of applying remotely sensed precipitation estimates (in this case from the Tropical Rainfall Measuring Mission [TRMM]) for forecasting inflows to the strategically important Toktogul reservoir in the Naryn basin, Kyrgyzstan. Correlations between observed precipitation at Naryn and 0.5° TRMM totals is weaker for daily ($r = 0.25$) than monthly ($r = 0.93$) totals, but the Naryn gauge is representative of monthly TRMM precipitation estimates across ~60% of the basin. The precipitations are estimated by remote sensing techniques and transferred to the reservoir. Over 80% of the variance in monthly inflows is explained with three-month lead, and up to 65% for summer half-year average. The analysis also reveals zones that are delivering highest predictability and hence candidate areas for surface network expansion.

In this study ASG range et al have developed a complementary modelling framework for improving real-time forecasting without needing to modify the pre-existing forecasting model, but instead formulating an independent additive or complementary model that captures the structure the existing operational model.. The application of this principle for issuing improved hourly inflow

forecasts into hydropower reservoirs over extended lead times, and the parameter estimation procedure reformulated to deal with bias, persistence and heteroscedasticity. The procedure presented comprises an error model added on top of an unalterable constant parameter conceptual model. This procedure is applied in the 207 km2 Krinsvatn catchment in central Norway. Deterministic and probabilistic evaluations revealed an overall significant improvement in forecast accuracy for lead times up to 17 h. Evaluation of the percentage of observations bracketed in the forecasted 95 % confidence interval indicated that the degree of success in containing 95 % of the observations varies across seasons and hydrologic years.

Hiroyukisuzuki et.al has estimated the amount of water inflow into a dam reservoir from the increment of hydrostatic water level in the constant time intervals. The data of water inflow is important for efficient dam operation. Therefore, the measurement of hydrostatic water level with high accuracy is important work to know the exact amount of water inflow. However, the data of water level is disturbed by the signals of wind wave, seiche and so on. The estimation method of hydrostatic water level is demanded from a dam administrator. This paper proposes the new estimation method of hydrostatic water level using IIR digital filter, and the effect of this filter is discussed. It is confirmed that the water inflow can be estimated using the new method. And the accuracy of estimation is discussed by investigating the variance of filter output.

The FYE(Firm yield estimator) methodology to estimate stream flow to the reservoir at an ungaged site was tested by simulating streamflow at two streamflow-gaging stations in Massachusetts and comparing the simulated streamflow to the observed streamflow. In general, the FYE-simulated flows agreed well with observed flows. There were substantial deviations from the measured values for extreme high and low flows. A sensitivity analysis determined that the model's streamflow estimates are most sensitive to input values for average annual precipitation, reservoir drainage area, and the soil-retention number—a term that describes the amount of precipitation retained by the soil in the basin. Firm yields for 25 (14 single-reservoir systems and 11 multiple-reservoir systems) reservoir systems were determined by using the historical records of streamflow and precipitation. Current water-use data indicate that, on average, 20 of the 25 reservoir systems in the study were operating below their estimated firm yield; during months with peak demands, withdrawals exceeded the firm yield for 8 reservoir systems. Introduction Growing demands on Massachusetts drinking-water supplies have increased the likelihood that withdrawals could deplete available storage capacity and result in supply shortfalls. A common way to evaluate reservoir behavior is by calculating a firm yield for the reservoir, defined as the maximum yield that can be delivered by the reservoir, even through a severe drought. Ideally, the firm yield would be determined from a period of record that included the worst drought likely to affect the reservoir. Firm-yield estimates typically are not based on streamflow and precipitation data that include the drought-of-record because these data are unavailable for most drinking-water supply reservoirs. Furthermore, even at monitored locations where streamflow and precipitation data are available, the length of the record often does not include the drought-of record. Because of these limitations, Massachusetts drinking Firm Yield and the Estimation of Firm Yield for Streamflow is to be properly evaluated during drought periods.

During an extreme event, having accurate inflow forecasting with enough lead time helps reservoir operators decrease the impact of floods downstream. Furthermore, being able to efficiently operate reservoirs could help maximize flood protection while saving water for drier times of the year. In this study Shenichi Yang &Tsun hua yang combined ensemble quantitative precipitation forecasts and a hydrological model to provide a 3-day reservoir inflow in the Shihmen Reservoir, Taiwan. A total of six historical typhoons were used for model calibration, validation, and application. An understanding of cascaded uncertainties from the numerical weather model through the hydrological model is necessary for a better use for forecasting. This study thus conducted an assessment of forecast uncertainty on magnitude and timing of peak and cumulative inflows. It found that using the ensemble-mean had less uncertainty than randomly selecting individual member. The inflow forecasts

with shorter length of cumulative time had a higher uncertainty. The results showed that using the ensemble precipitation forecasts with the hydrological model would have the advantage of extra lead time and serve as a valuable reference for operating reservoirs.

In the present study the CWC gauged data available at various gauge sites is transferred to Almatti and the net flows are arrived at on monthly basis. The results are compared with the actual observed data at Almatti for the period 2003-2007.

3. METHODOLOGY FOR THE PRESENT STUDY

Almatti reservoir receives flows from sub basins K1, K3, and part of K2 of Krishna basin. The gauge data at Kurundwad and Sadalga was used to estimate the gross flows of K1 sub basin. Similarly Bagalkot station and galgali is used for K3 and K2 respectively. For the period when the data at these gauge sites is not available other nearby sites are used. The reservoir working table data was used to develop the gross flows at the reservoir site. Whenever the reservoir data is not available the catchment rain fall proportions are used to develop the gross flow series at that reservoir. For the first reservoir in the sub basin the net flows are worked out as the gross flows minus the planned upstream utilisations including minor irrigation and small projects upstream of reservoir. The intermediate flows from 2nd to first are worked out by taking the difference of gross flows of the two reservoirs. The flows are routed through the first reservoir considering the planned utilisations of that project. The spills and the intermediate gross flows less the minor irrigation and the small projects in the catchment of first to second reservoir form the net flows in reservoir2. These flows are again routed considering the planned utilisations from the second reservoir to the third ans so on till the gauge site. The net flows that flow from the gauge site are then worked out at the end of sub basin at the gauge site. This process is done for all the three sub basinsK1,K2, and K3. The monthly planned utilisation pattern is derived at based on 10 year average utilisation of major projects. The utilisations are considered as provided in the awards. The catchment contribution below the gauge sites is worked out with catchment and rain fall proportions and minor irrigation deducted from the same. This is then added to the flows from K1, K3 and K2 to get the net flows at Almatti.

The net flows at Almaati are shown in Table 2.

Table 2 Monthly net inflows in to Almatti reservoir

Monthly net inflows in to Almatti reservoir													
Year	**june**	**july**	**Aug**	**sep**	**oct**	**nov**	**dec**	**jan**	**feb**	**mar**	**apr**	**may**	**total**
1972	0.21	144.38	43.22	17.62	4.68	1.18	0.89	0.98	0.95	0.9	0.96	0.84	216.81
1973	6.38	226.29	163.21	96.62	37.73	6.881	1.82	1.91	1.76	1.98	1.19	4.08	549.85
1974	0.17	140.52	166.96	58.19	75.01	11.29	1.87	2.26	1.87	1.31	1.04	1.04	461.53
1975	38.42	227.82	219.4	117.18	109.67	38.45	4.21	3.49	2.6	2.16	1.6	1.36	766.36
1976	51.08	190.43	242.66	91.81	15.32	2.71	2.04	2.23	2.06	1.81	1.5	2.99	606.64
1977	32.15	200.8	121.1	112.31	32.14	12.3	9.22	3.38	3.12	2.16	2.66	3.02	534.36
1978	50.63	128.49	271.96	114.55	18.82	5.68	2.67	3.34	2.91	2.04	1.48	1.21	603.78
1979	7.08	75.2	311.55	72.76	32.33	7.9	3.12	3.1	2.8	1.82	2.37	7.94	527.97
1980	22.47	219.56	300.98	56.8	10.41	2.51	2.15	2.72	2.51	1.73	1.38	1.05	624.27
1981	0.17	166.2	250.48	88.48	23.91	3.54	2.99	3.51	3.08	2.41	1.43	1.97	548.17
1982	1.31	89.12	255.86	20.08	8.5	4.59	2.77	3.17	2.61	2.12	1.49	1.12	392.74
1983	35.94	165.86	266.38	63.26	14.15	1.95	2.25	2.54	2.25	2.11	1.9	1.45	560.04
1984	1.3	151.86	136.13	36.41	19.14	3.61	2.9	3.1	2.49	2.48	1.97	1.2	362.59
1985	6.85	78.82	188.5	13	26.62	1.99	2.7	3.11	2.25	2.09	1.77	1.8	329.5
1986	13.5	89.15	160.64	7.48	4.64	3.25	1.75	2.27	1.99	1.71	1.6	1.39	289.37
1987	0.17	67.35	57.33	19.48	10.81	0.85	1.59	1.3	1.27	1.42	1.44	1.02	164.03

1988	0.17	172.11	182.75	106.96	26.74	1.31	2.31	2.57	2.31	1.85	1.56	1.15	501.79
1989	3.36	149.39	112.51	39.38	17.12	1.66	2.27	2.39	2.16	1.63	1.02	4.53	337.42
1990	0.78	173.5	268.12	81.04	28.46	8.11	1.97	2.35	1.75	1.47	1.8	1.2	570.55
1991	55.51	226.17	314.89	44.37	24.84	1.98	2.61	4.26	3.62	2.52	1.39	0.81	682.97
1992	0.17	80.34	190.08	66.14	16.42	2.71	2.57	2.85	2.04	1.69	0.96	0.65	366.62
1993	18.66	171.34	256.39	62.01	113.24	10.76	11.29	8.08	6.55	5.28	6.56	3	673.16
1994	49.76	611.76	218.36	262.98	30.05	4.03	2.42	10.03	2.74	1.8	1.7	1.2	1196.8
1995	0.17	77.87	58.3	77.66	56.65	4.04	2.76	2.87	2.26	1.42	0.95	0.98	285.93
1996	5.33	109.24	128.79	30.31	139.87	8.86	4.03	5.25	2.7	1.93	1.1	2.55	439.96
1997	12.84	170.96	488.9	54.11	13.3	11.3	7.53	3.38	2.82	2.78	1.94	1.21	771.07
1998	2.08	122.93	115.79	71.73	117	12.02	2.44	2.83	3.41	3.8	3.12	5.98	463.13
1999	40.48	248.08	138.76	29.34	101.96	10.27	2.29	3.08	2.48	1.58	2.56	2.69	583.57
2000	7.29	94.18	60.62	61.15	35.39	2.42	0.95	1.17	0.92	0.88	0.87	0.51	266.35
2001	3.85	87.07	85.27	19.5	23.78	0.57	0.77	0.87	0.48	0.44	0.49	0.42	223.51
2002	6.5	45.02	136.57	19.55	12.97	0.38	0.73	1.1	1.19	1.41	1.35	0.99	227.76
2003	10.38	69.04	59.35	21.93	1.56	0.21	0.19	0.67	1.19	1.18	0.87	0.42	166.99
2004	51.08	34.44	266.93	31.77	14.2	1.25	1.41	1.4	1	1.04	1.05	1.05	406.62
2005	7.38	261.27	578.68	223.85	26.4	1.42	1.58	1.76	1.7	1.59	1.41	1.22	1108.3
2006	26.32	275.67	639.49	95.16	31.9	1.14	1.78	1.79	1.78	1.63	1.51	1.38	1079.6
2007	26.83	292.65	237.84	136.57	21.89	1.81	2.02	2.34	2.45	2.05	1.64	2.18	730.27

The actual net flows observed during the period 2003-04 to 2007-08 at Almatti are given in Table 3.

Table 3 Actual observed flows in Almatti reservoir

Actual observed flows in Almatti reservoir					
Month	**2003**	**2004**	**2005**	**2006**	**2007**
June	21.21	70.12	5.74	32.78	38.897
July	75.28	39.12	223.6	287.76	338.604
August	61.58	306.05	577.01	621.15	206.398
September	22.55	29.78	213.38	81.9	119.147
October	3.04	15.80	43.08	23.53	22.8
November			1.5	0	0
December				0	0
January				0	0
Febraury				0	0
March				0	0
April				0	0
May			0.67	0	0
Total	**183.66**	**460.87**	**1064.98**	**1047.12**	**725.85**

4. RESULTS AND DISCUSSIONS

It could be seen that the average inflows on annual basis in the ultimate scenario in to Almatti will be 486.71 TMC. The Maximum inflow in to the Almatti in ultimate condition will be 1033.91 TMC whereas the minimum net flow in ultimate condition will be very low and will be 98.59 TMC. A comparision of table 2 and table 3 shows that there will be a reduction of 16.67,54.27 TMC in the

annual flows at Almatti in the years 2003-04 and 2004-05 from the present scenario to the ultimate scenario when full development upstream takes place.

In good years there is no much variation in the annual flows. This is because of the increase in storage at Almaati from 123 TMC to 220 TMC. The flows in June have reduced by 10.83,19.04,6.46 and 12.10 TMC in the years

2003,2004,2006 and 2007. This is due to the reason that these flows will be stored upstream and flows will come only after the storages are filled up or the generation below gauge sites is considerable. In 2005 there is no reduction in june but the variation is small. This small variation may be due to storage effects of Almatti and other projects up stream of Almatti.

The flows in july have reduced by 6.24,4.68,12.09 and 45.954 TMC in the years 2003,2004,2006 and 2007. This is due to the reason that these flows will be stored upstream and flows will come only after the storages are filled up or the generation below gauge sites is considerable. In 2005 there is no reduction in july . This variation may be due to storage effects of Almatti and other projects up stream of Almatti. IT could be seen that there are non mosoon flows in the ultimate scenario this is because the releases ordered by Tribunal for minimum environmental flows and releases to Chennai water supply to be supplied by upstream projects to Almaati.

5. CONCLUSIONS

From the above study it can be concluded that the average inflow into Almatti will be 574.86 TMC, the maximum inflow will be 1196.8 TMC and the minimum flow will be 166.99 TMC. The flows in Annual in deficit years may reduce by about 50 TMC but there is no variation in the good years as the storage effects will take care of this aspect during good years. It can be concluded that there will be reduction of flows in the June and July flows in the ultimate scenario except in very good years. There will be some minimum flows in the non-monsoon in the ultimate scenario to take care of environmental aspects and Chennai water supply.

REFERENCES

[1] Chaw Dung et.al-estimation of non-fluctuating reservoir inflow from water level observations using methods based on continuity- Journal of Hydrology, Vol.529,Part3 oct 2015, p.1198-1210

[2] Samuel G. Dixton, Robert l. Wilby- Fore casting reservoir inflows using remotely sensed precipitation estimates- A pilot study for thr river Naryn, Kyrgyzstan-Hydrological sciences- Vol 16,2016, Issue1

[3] AS Grange et.al-Improving real time inflow forecasting in to hydropower reservoirs through a complimentary model frame work- Hydrology and earth sciences, 27 th aug,2015

[4] 4.Hiroyuki et.al- A new estimation of inflow in to dam reservoir using digital filter- Japan society of civil engineers, Vol 2001,(2001) No. 677, p.1-19, released in 2010

[5] USGS-Factors effecting firm yield and the estimation of firm yield for selected stream flow dominated drinking water supply reservoirs in Massachusetts- Usgs scientific report 2006,5094

[6] Shenin chi yang & TSun yua Yang- uncertaintity assessment in reservoir inflow forecasting with eon senble precipitation forecasts and HMC, HMS-Advanced meterology, Volume 2014,11 pages, A.I.9-581756

[7] CWC gauge data record of Krishna basin 1972- 2007

[8] Almatti inflow observations 2003-2007

[9] Almatti project report

[10] KWDT1 & KWDT2 awards

[11] Patil R.A. and Shetkar R.V., Prediction of Sediment Deposition in Reservoir using Artificial Neural Networks. *International Journal of Civil Engineering and Technology*, 7 (4), 2016 , pp. 01–1 .

[12] Maharam Dakua, Asef Mohammad Redwan, Begum Nazia Jahan, Syed Mohammed Tareq, Saifuddin Ahmed and Nowroz Farhan Noor, A Case Study on Management of Rainwater Reservoir in Hilly Areas of Bangladesh. *International Journal of Civil Engineering and Technology (IJCIET)*, 7(6), 2016, pp.193 – 201.

[13] Mohamed Ayman El Salawy, Tamer Ali Elgohary, Amir Mohamed Akl Mobasher and Mai Mahmmoud Abd El Aziz, Impact of Climate Change on Resrevior Operation Policies–The Case of Aswan High Dam Reservoir, *International Journal of Civil Engineering and Technology*, 7(2), 2016, pp. 107–116